Biological Odor Control Overview and Design Considerations

FWEA Air Quality Seminar

Tavares, FL

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CDM Smith

WATER + ENVIRONMENT + TRANSPORTATION + ENERGY + FACILITIES

Discussion Topics

- Biology
- Types of Biological Odor Control
  - Biofilters
  - Biotrickling Filters / Bioscrubbers

Section 1- Biology of Biological Odor Control

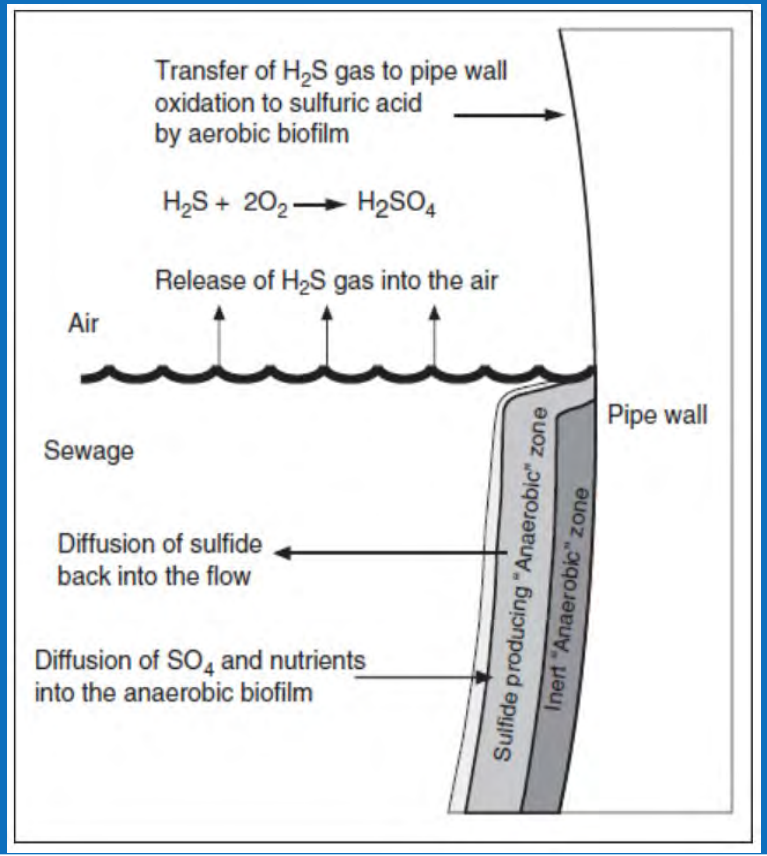
Biology of Odorant Formation

- Biological processes form a majority of offensive odors associated with wastewater
  - Microbial degradation
  - Sulfide generation
  - Anaerobic biological processes

Thiobacillus

$$H_2S + 2O_2 \rightarrow H_2SO_4$$

- Prefers to live suspended as thin sheets
- Grows on sewer surfaces above waterline and typically invisible to naked eye
- Convert chemicals faster than heterotrophs
- Byproduct sulfuric acid (H_2SO_4) associated with corrosion of concrete and metals
- The majority of hydrogen sulfide gas never leaves the sewer system and is biologically converted to sulfuric acid



Biogenic Odorants

- Inorganics
  - ***Hydrogen sulfide (H_2S)***
  - Ammonia (NH_3)
- Organics (e.g. VOCs)
  - Mercaptans
  - Sulfides
  - Amines
  - Skatoles & Indoles

Detection levels in the parts per billion!

If Biology Caused This, Why Not Use Biology to Fix This?

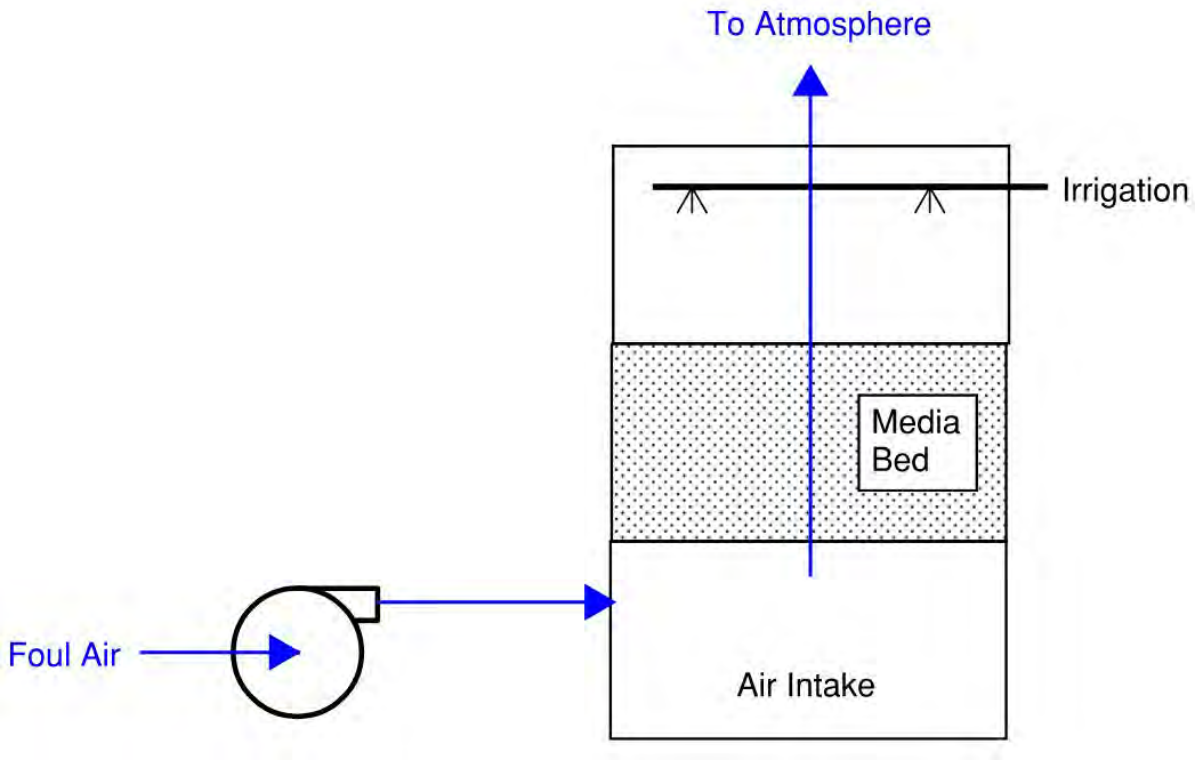
Biology of Biological Odor Control

- Main biological processes used in biological odor control
  1. Autotrophic Degradation
  2. Heterotrophic Degradation

	Autotrophs	Heterotrophs
Degradation	Inorganics (H_2S, NH_3)	Organics (VOCs)
Environment	Acidic (2 – 3 pH)	Neutral (7 – 8 pH)

Section 2- Biological Odor Control Treatment Systems

Typical Biological Odor Control System



Major Biological Odor Control Systems (In Chronological Order)

In-Ground Biofilters

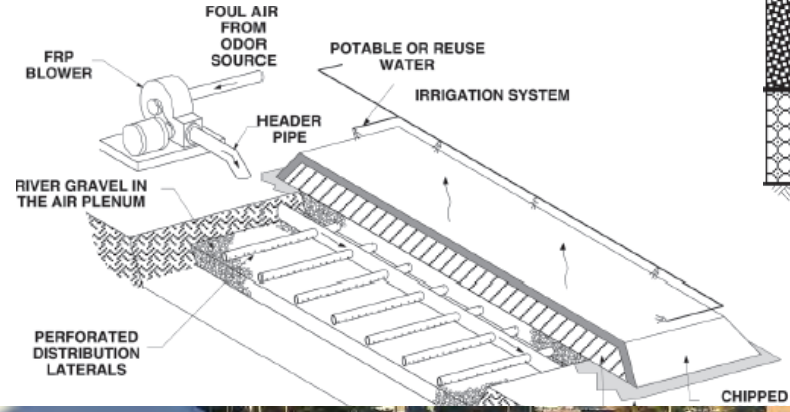
In-Vessel Biofilters

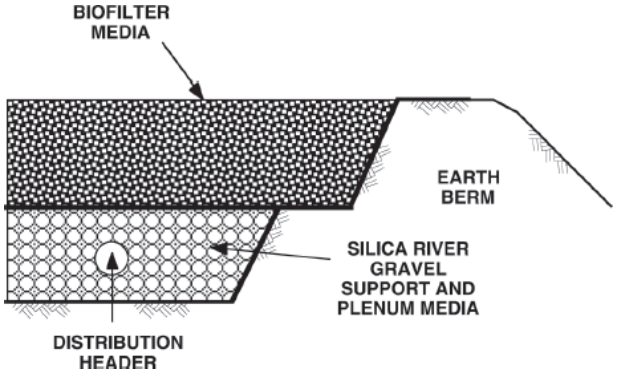
Modular Biofilters

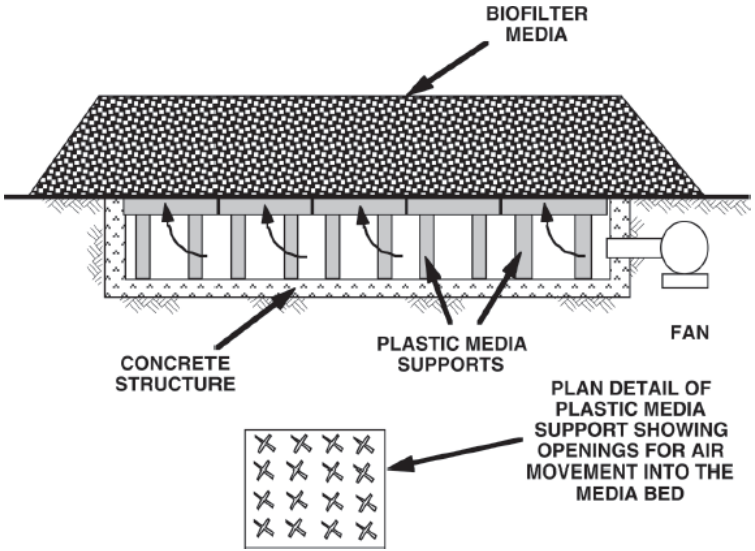
Biotrickling Filters

Section 2.1- In-Ground and In-Vessel Biofilters

In-Ground Biofilters



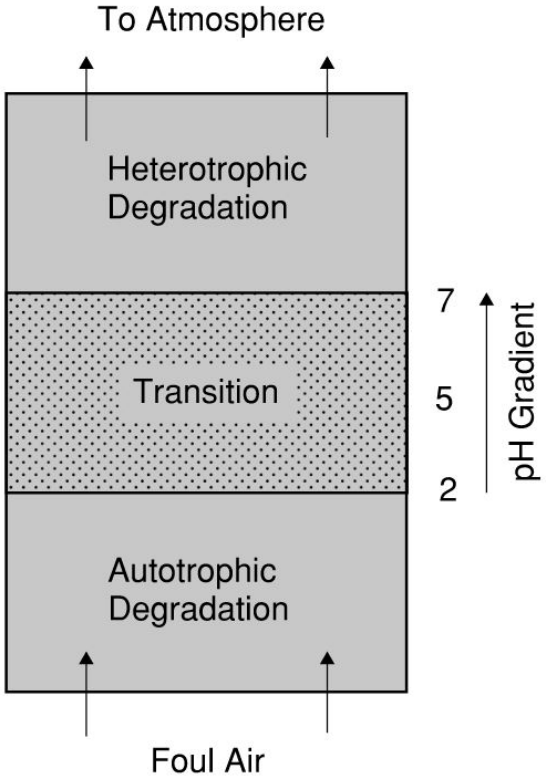




In-Vessel Biofilters

Biofilters: Media Cross-Section

- Typical media bed thickness: 48-inches
  - If media bed is too thick, media will compress under its own weight and lower quantity of air flow
- Autotrophic Degradation: Inorganics (e.g. H_2S and NH_3)
- Heterotrophic Degradation: Organics
  - Heterotrophic Degradation can usually be incorporated as a polishing stage
- Ideal cross-section breaks down at high H_2S loading levels, increases size of "Autotrophic Degradation" zone
- Empty Bed Residence Time (EBRT)



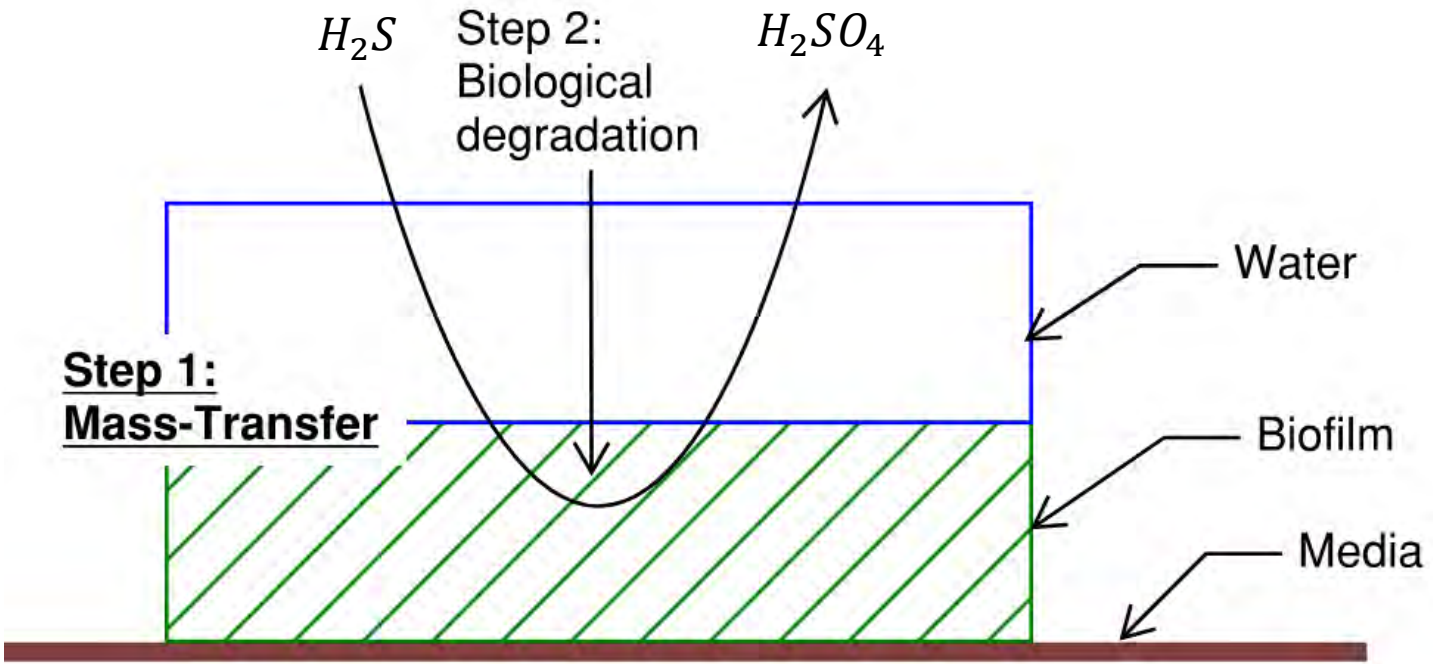
Empty Bed Residence Time

- Depends on inlet composition and desired performance
- Function of media surface area, media height, and inlet volumetric flow rate

$$EBRT = \frac{Qh}{A}$$

Q = inlet flow rate, cfm
h = media height, ft
A = surface area, ft^2

Biofilters: Media



Biofilters: Organic Media

- Stabilized Woodchip or Bark
  - Stabilized = Dried out
  - Relatively resistant to biological breakdown
  - Want large chunks for biofilm
- Compost
  - Partially degraded organic material
  - Mineralized organic matter
  - Contains autotrophs and heterotrophs

Biofilters: Organic Media

- Avoid Processed Construction and Demolition Material
  - Usually poorly and unevenly processed
  - Want uniform media chunks
  - Non-uniform media chunks cause channeling
  - May contain hazardous materials, adhesives (e.g. plywood), metals

Biofilters: Bark Media Bed

Section 2.2- Modular Biofilters

Modular Biofilters

- Easy to design, predictable, and more reliable
- Easier to changeout media
- Longer media life
  - Canopy maintains media consistency
  - Encasement prevents subsidence of media
  - Encasements controls drainage

	Empty Bed Residence Time, sec	Velocity, ft/min
In-Ground Biofilter	30 – 60	3 – 5
Modular Biofilter	30 – 40	10 – 15

Modular Biofilters: Inorganic Media

- Proprietary media using a combination of highly refractory support media with nutrients
- Higher velocity
- Lower Empty Bed Residence Time (EBRT)
- Steady pressure drop
- Less channeling, more uniform
- Carries a long media warranty of ten years, can last 15 years

Modular Biofilter- Modern Installation

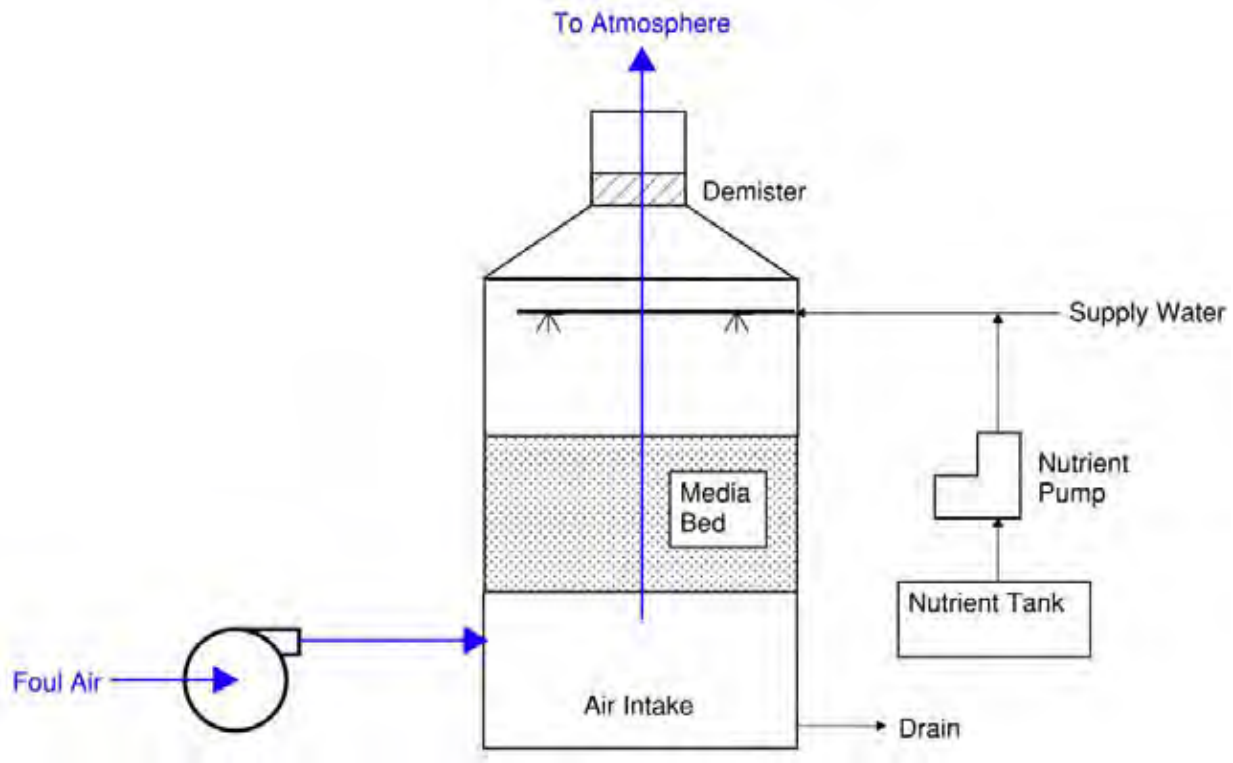
Section 2.3- Biotrickling Filters

Biotrickling Filters

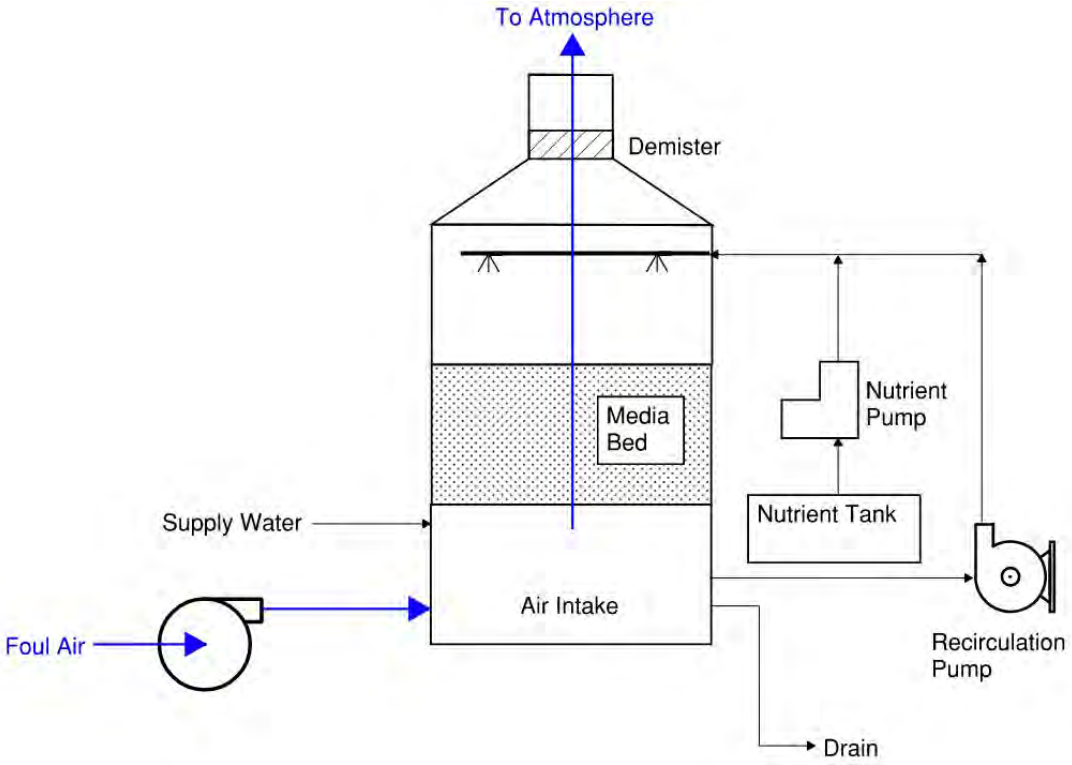
- Also known as bioscrubbers and biotowers
- Main Operational Strategies:
  1. Once-through mode
  2. Recirculation mode

	Empty Bed Residence Time, sec	Velocity, ft/min
In-Ground Biofilter	30 – 60	3 – 5
Modular Biofilter	30 – 40	10 – 15
Biotrickling Filters	6 – 20	60 – 140

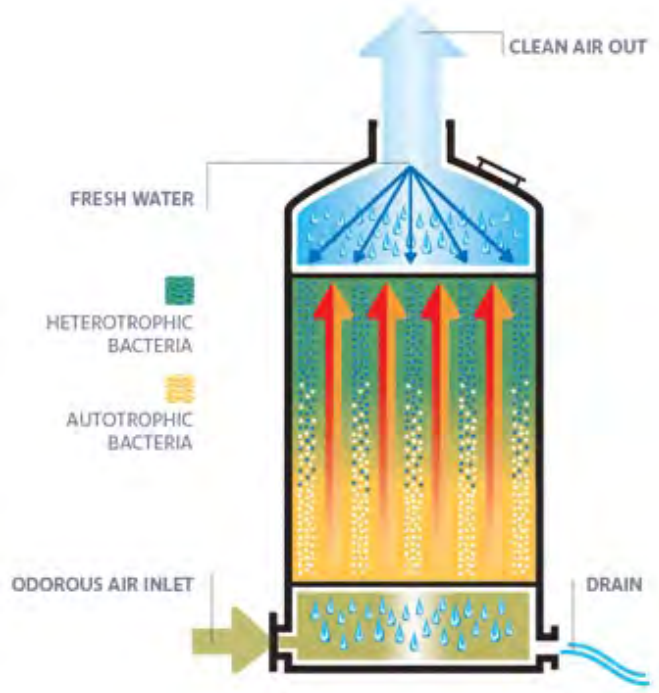
Biotrickling Filters: Once-Through Mode



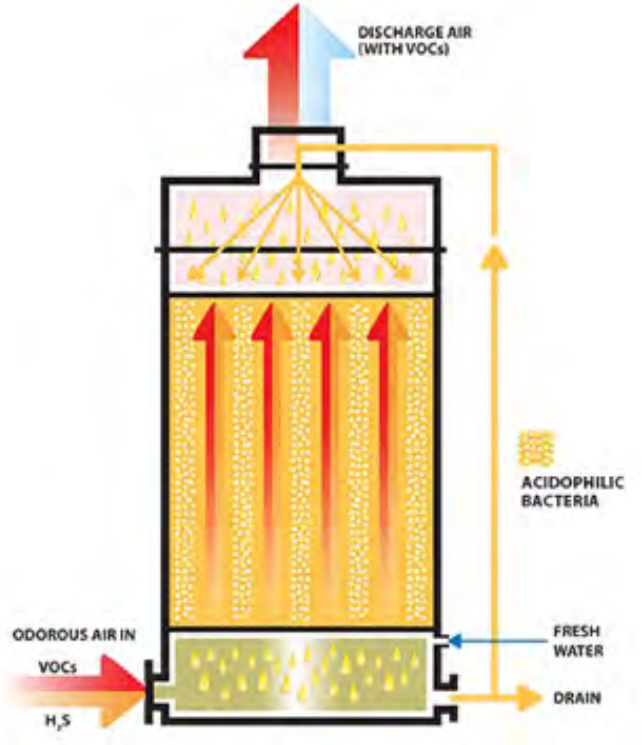
Biotrickling Filters: Recirculation Mode



Fresh Water Mode



Recirculation Mode



Biotrickling Filters: Design Considerations

1. Operational Strategy
2. Shape
3. Supply Water Quality
4. Inlet Foul Air Composition
5. EBRT
6. Stages
7. Temperature
8. Recirculation and/or Booster Pumps
9. Irrigation
10. Nutrients
11. Water Panel
12. Access Ladders and Platforms
13. Manways
14. Media
15. Demister
16. Outlet stack
17. Drains
18. Gauges and Meters

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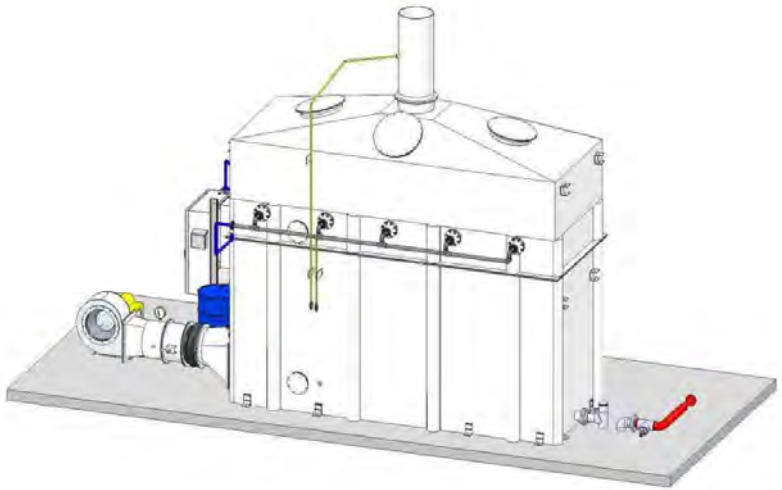
Biotrickling Filter: Shape

Vertical Tower



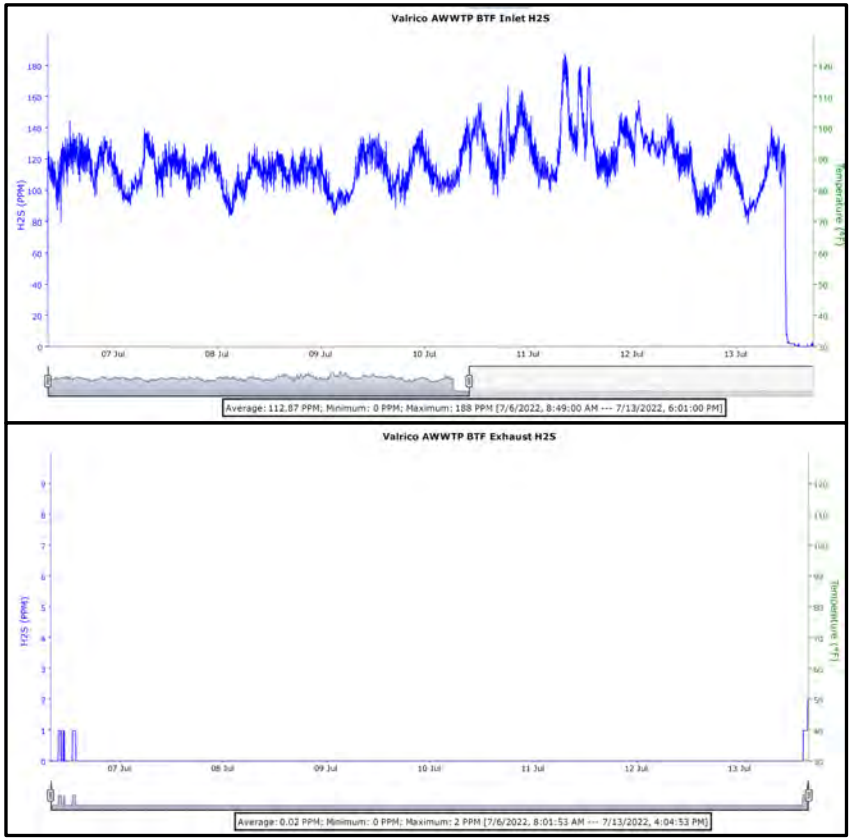
Low Profile

Biotrickling Filter: Supply Water Quality

- Chemicals that deter bacterial growth:
  - ***Chlorine***
  - Hardness
  - Total Suspended Solids
- Chemicals that encourage bacterial growth:
  - Total Kjeldahl Nitrogen
  - Phosphorous
  - Oxygen

Biotrickling Filter: Inlet Foul Air Composition

- Inorganics
  - ***Hydrogen sulfide (H_2S)***
  - Ammonia (NH_3)
- Organics (e.g. VOCs)
  - Mercaptans
  - Sulfides
  - Amines
  - Skatoles & Indoles
- SAMPLE!!

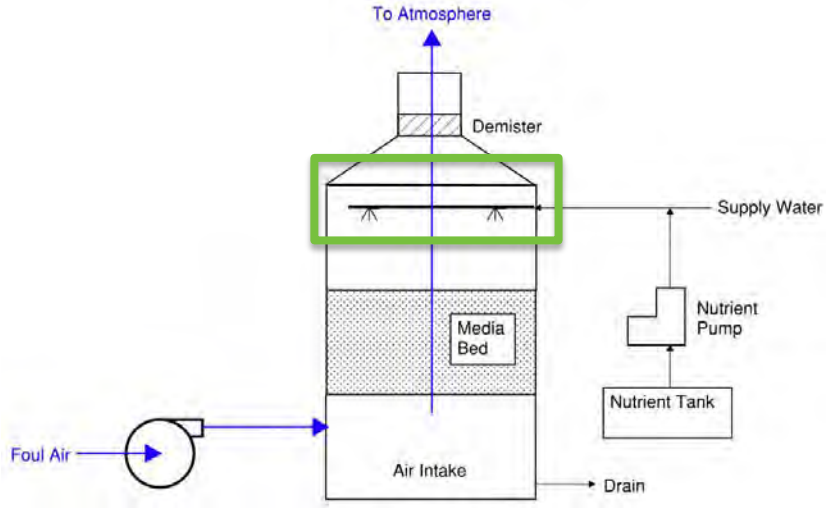


Biotrickling Filter: Recirculation/Booster Pumps

- Recirculation Pump(s)
  - Temporarily used for acclimation
  - Permanently used for recirculation mode
  - Built for pumping corrosive liquids
- Booster Pump(s)
  - Used to boost supply water to irrigation nozzles

Biotrickling Filter: Irrigation

- Full cone nozzles at top of system
- On intermittent timer to supply appropriate amount of water



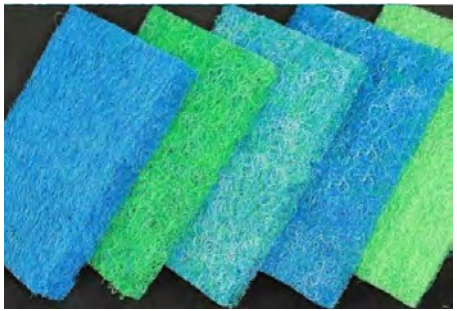
Biotrickling Filter: Nutrients

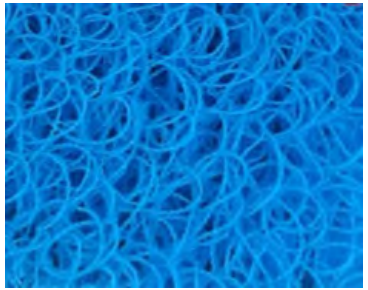
- Nutrients (nitrogen, oxygen, phosphorus, etc) to supply to bacteria to help grow
- If bacteria already have enough food, giving them nutrients will foul up system
- Nutrient feed pump usually housed in water panel

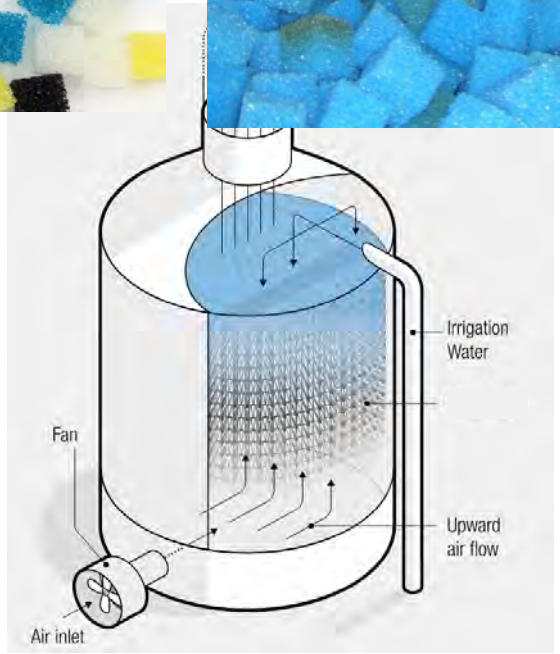
Biotrickling Filter: Water Panel

Biotrickling Filters: Media

- Two types of media:
  1. Random
  2. Structured
- Media treated well can last 10-15 years
- Densities of media can be mixed depending on the desired biofilms to form

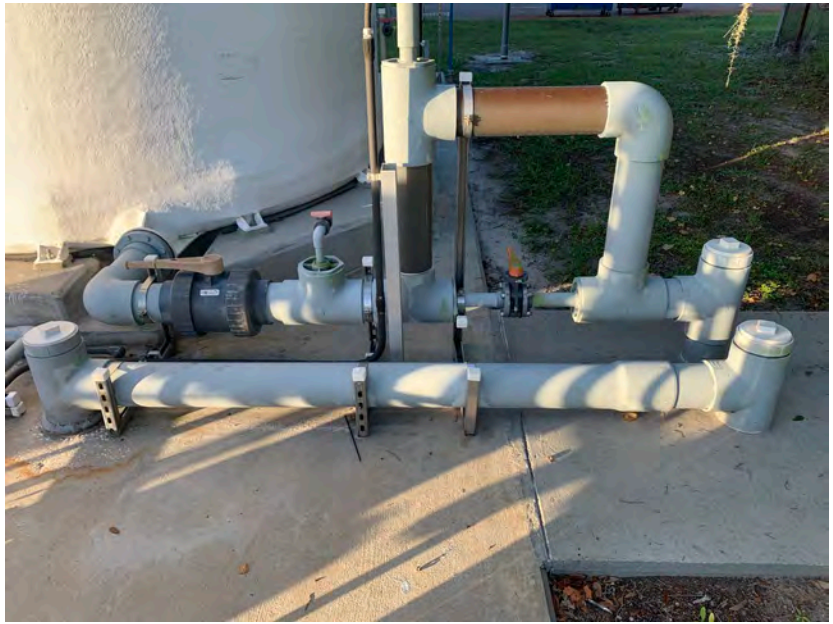






Biotrickling Filter: Drains

- All condensate drains trapped
- Special drain on biotrickling filter sump



Biotrickling Filter: Gauges and Meters

Section 3- Closing Thoughts

Biological Odor Control: Periodic Monitoring

- Moisture Content
  - Water supply pressure
  - Nozzle pressure
  - Total water use over time
  - Chlorine content in supply water
- Pressure Drop
- Airflow
- Performance
  - Hydrogen sulfide removal over time
- Mechanical Problems
  - Leaks in vessel and appurtenances
  - Blower noises and vibration

Conclusions

- Biological odor treatment is an effective odor control technique when design rules are followed

	Autotrophs	Heterotrophs
Degradation	Inorganics (H_2S, NH_3)	Organics (VOCs)
Environment	Acidic (2 – 3 pH)	Neutral (7 – 8 pH)

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